Biology News

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UNIVERSITY OF OXFORD

Department of Plant Sciences
Department of Zoology

Liam Dolan Head of Plant Sciences Department

A major focus of both our departments is to train the next generation of biologists and world citizens in an excellent research culture that builds on the resources that we curate – the fossils in the museum, herbarium specimens, plants in the botanic garden and increasingly the large data sets. From this scientific activity we will make discoveries about how the world of nature works and how it has worked since life first evolved.

The Department is building on these discoveries to determine how this knowledge can be used to address challenges faced by the society in general. These discoveries can provide evidence to policy makers in the public, non-governmental organization sectors and private sectors, to provide evidence to enable decision–making. There are a number research programs that highlight the breadth of activity in this sector.

Robert Scotland is driving a program to understand the taxonomic relationships the characteristics of groups of plants from which domesticated crops have been bred. In addition to resolving species and their relationships, this work forms a framework for harnessing this natural diversity as source of new genetic variation and may identify potentially new crops for the future.

John Baker

Genomics – technology that allows the sequencing and analysis of large amounts of DNA – has revolutionized our ability to manage our soil resources because the microbial flora is indicative of the health of a soil and also of its potential agricultural productivity. Phil Poole and Andrzej Tkacz have developed technology that allows the use genomics to evaluate the community of microorganisms in agricultural soils to help farmers more efficiently manage their resources and preserve soil health.

Our ability to address global challenges is entirely dependent on our ability to carry out the highest standards of fundamental research and there has been recognition of outstanding scientific achievement in 2015.

Professor Jane Langdale was made a Fellow of the Royal Society for her discoveries in plant developmental biology. Jane discovered key elements of the genetic mechanism underpinning the evolution of leaves and shoots and identified the first genetic regulators of photosynthetic cell differentiation. It is this foundation of fundamental knowledge that has a convinced the Bill and Melinda Gates Foundation to fund her ambitious program in transforming rice yields by increasing its photosynthetic efficiency for the past 6 years.

We have been working closely with other elements of the University to harness our discoveries to deliver them to end users and stake holders. Marshaling support from the Business Development team, the Development team, Research Services and the University of Oxford Technology Transfer and commercialization company, Isis Innovation we are developing a strategy to maximize the impact of our research. We are already seeing successes with plans for the development of spinout companies and research contracts with industry. Our close partnerships with the Department of Zoology is crucial to make the most of the unique opportunity.

Graduate student projects

Genetic basis of root secretions in plant symbioses

James Wheeler, Linacre College

Mara Carraro

Nitrogen fertiliser use is one of the biggest input costs for agriculture and is unsustainable in the long term. Biological nitrogen fixation offers a sustainable alternative, particularly in the form of the symbiotic interaction between legumes and rhizobia. Root exudates play key roles in early legume-rhizobia signalling. Using bacterial biosensors to visualise root secretion in vivo, my research dissects the genetic basis of root secretion in the model legume *Medicago truncatula*. The overall aim is to further our understanding of signalling interactions between these two parties to facilitate more effective use of this symbiosis in biotechnological and agricultural contexts.

Agriculture and Conservation

Claudia Havranek, Magdalen College

Claudia Havranek

We are currently faced with both a huge increase in food demand, and a global extinction crisis. Nearly 40% of the earth's land surface is committed to agriculture, however the idea of conservation on agricultural land increasing crop yield is relatively new.

My fieldwork, based on the Ditchley Park Estate, Oxfordshire, addresses these ideas on a local level. I am identifying the key landscape elements that most effect plant species diversity and crop yield, and identifying what scale (farm, landscape, regional) we should address species conservation in agroecosystems over. This may then be used to identify practical land management strategies to maximise food production and conservation.

Getting to the root of plant roots

Sandy Hetherington, St Catherine's College

Anna Thamm

Roots provide the primary interface between land plants and the terrestrial surface. Their evolution transformed the Earth system, fundamentally changing weathering rates, nutrient fluxes and fluvial processes. For such an important innovation it might, therefore, seem surprising that roots have evolved independently in two major lineages of land plants: the lycophytes (clubmosses) and the euphyllophytes (plants with true leaves – such as ferns and angiosperms). In my DPhil I am using next generation sequencing to identify the first regulators of roots developed in the lycophytes allowing me to test if the independent origin of roots used similar or different genes in the two lineages.

Peter Holland Head of Zoology Department

The past year has been one of tension and anticipation across UK Universities as we awaited the results of the Research Excellence Framework (REF): a complex system that attempts to measure quality of research in UK Universities. I could write at length about the usefulness and the shortcomings of the REF, but will restrain myself and simply comment that whenever a set of rules is created there will always be game-playing and perhaps a danger of the tail wagging the dog. Our ethos in Oxford has always been to foster and support important research and high quality teaching regardless of external assessment. Having set the scene, I can report that the REF results for Oxford were exceptional. In biology, the REF does not notice departmental boundaries, and so research in Zoology and Plant Sciences was submitted together with four other more biomedical departments in Oxford. Together, the REF ranked Oxford biological sciences as number 1 in the UK for volume of world-leading research, and 93% of our combined submission was classed as world leading or internationally excellent.

This has been a year of change for graduate training. The University's central Clarendon Fund scheme for scholarships is over-stretched, and gone are the days when Research Councils gave Departments 'quota' studentships to allocate to top students.

Jordi Paps

New funding routes are available, however, and these combine to make the picture for graduate funding promising again. Many of our graduate students now enter cross-departmental 'Doctoral Training Programmes' (DTPs) which include training courses before students commence research, comparable to a US Graduate School model. In October 2014, the first 24 graduate students entered Oxford's NERC DTP in Environmental Research, while our BBSRC DTP in Interdisciplinary Bioscience grows to a similar size in 2015. Excitingly, we will also welcome our first small cohort of graduate students with scholarships from within the Department, using funds generated by the successful spin-out company NaturalMotion, founded by alumnus Torsten Reil. We still do not have enough funding to support all exceptional applicants, however, and we are keen to hear of new potential funding sources including funds for named scholarships.

I must also congratulate several members of the Department on various awards and medals. The Zoological Society of London (ZSL) makes a number of awards and this year Oxford won about half of them! The ZSL Award for the best undergraduate project in the field of zoology went to Benjamin Hopkins, the ZSL Award for the best PhD thesis in zoology went to Ben Ashby, the ZSL Silver Medal for outstanding contributions to the understanding and appreciation of zoology went to Darren Mann, and the highly prestigious ZSL Scientific Medal went to Tommaso Pizzari. Turning to other organisations, Jen Perry was awarded the Christopher Barnard Award for Outstanding Contributions by a New Investigator from the Association for the Study of Animal Behaviour, Jeremy Thomas won a NERC societal impact award for his work on conservation of the Large Blue butterfly, and Herizo Andrianandrasana was awarded the 2014 Tusk Award for Emerging Leaders in Conservation, of which more later in this issue.

Graduate student projects

Gastropods from hydro-thermal vent ecosystems of Indian and Southern oceans

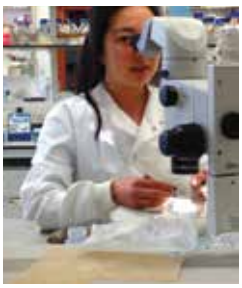
Chong Chen, Merton College


Alfred Aquilina

Deep-sea hydro-thermal vents derive energy not from light but chemical reactions (chemosynthe-sis). My research focuses on the systematics, ecol-ogy, and evolu-tion of endemic gastropods from recently discovered vents, in particular how they have adapted to live in this 'extreme' environment and how distant populations are connected. I recently described and named the 'scaly-foot gas-tropod', *Chrysomallon squamiferum*, which has unique iron-sulphide coated sclerites on the foot and I am revealing its unique ways of life in vents through 3D reconstruction of the anatomy. The sclerites superficially re-semble those of extinct Cambrian taxa, and I am comparing fossils with my living snails.

Symmetry and asymmetry in animal development

Erica Namigai, St Hilda's College


Sebastian Shimeld

A long-standing enigma in animal development has been how symmetry is broken during embryogenesis to produce an asymmetric adult body. I am interested in symmetry breaking and am analysing the dynamics of early cell division in embryos of the fanworm *Pomatoceros lamarkii*, a polychaete annelid. I am utilising an amalgamation of techniques which include live imaging and molecular biology. My results contribute to an understanding of chirality (the appearance of asymmetry in development) in early embryos, with an ultimate goal of understanding how symmetry breaking mechanisms evolved in bilateral animals.

Interactions between avian colonial social structure and disease dynamics

Klara Wanelik, St John's College


Jacob Bishop

Increased transmission of parasites and pathogens is thought to be a major cost of coloniality. However, infection risk can be modified by the social behaviour of individuals within the colony. I am investigating this in a population of common guillemots on the Isle of May, Scotland that are infected by a tick-borne virus, *Great Island Virus*. Observed colony attendance patterns and inferred infection rates of known-aged guillemots suggest that individual immature guillemots may play a critical role in driving pathogen dynamics, and exposure to this pathogen is likely to be both spatially and temporally heterogeneous within the breeding colony.

Botanical illustration in the Department of Plant Sciences

Botanical illustration has been and continues to be a critical activity in the scientific description of plants. In the late 18th century Ferdinand Bauer illustrated *Flora Graeca* the magnus opus of the then Sherardian Professor of Botany, John Sibthorp. In January 2015, Rosemary Wise, botanical artist, celebrated 50 years in the Department of Plant Science. In that time Rosemary has produced over 12,000 botanical illustrations. She is currently working on a large collection of drawings of plants in the genus *Ipomoea*, which includes the sweet potato and other species that have potential as future food crops. This is part of a project being carried out by Robert Scotland and John Wood to describe this systematics of this group of plants.

Rosemary has also just completed a reconstruction of the stigmarian system, the rooting system of giant trees from Carboniferous coal forests. Sandy Hetherington's analysis of 320 million year old fossils has revealed that the structure of these rooting structures has been misinterpreted since they were first discovered over 170 year ago. Last year, Rosemary produced what may be one of the last illustrations of the black pine (*Pinus nigra*) also known as Tolkien's tree from the Oxford Botanic Garden. The tree was felled after dropping a number of its largest branches in July 2014. The pine illustration not only highlights her skills in detailed scientific illustration but also demonstrates the great beauty of her images.

Liam Dolan

Rosemary Wise

Undergraduate student projects

The effects of neonicotinoid insecticides on bees

Fergus Chadwick, Somerville College

James Evry

There has been growing concern recently about the effects of neonicotinoid pesticides on beneficial insects such as bees, culminating in a two year moratorium on their use in much of the EU. Working with the Centre for Ecology and Hydrology (CEH), I took a novel approach to assessing the risk they pose by using the foraging behaviour of individual bees to determine how likely they were to be exposed to the pesticides in the field. My results showed that neonicotinoids were attractive to multiple bee species, potentially meaning that bees will suffer a higher exposure than previously thought.

A comparative study of Strouhal number in birds

Patrick Meyer Higgins, Corpus Christi College

S. Duncan

I investigated aerodynamics in avian flight: I used a high speed video camera to film wild birds in unperturbed flight, and (providing certain assumptions were met) measured the amplitude and wavelength of the waveform of the birds' wing beats, allowing calculation of Strouhal number (St). St is a dimensionless quantity describing vorticity in the wake; propulsive efficiency and aerodynamic force coefficients are known to be high in certain ranges of St. I found that flight mode (e.g. cruising flight or flight in ground effect) had a significant effect on St, indicating that different performance objectives are maximised in different flight modes.

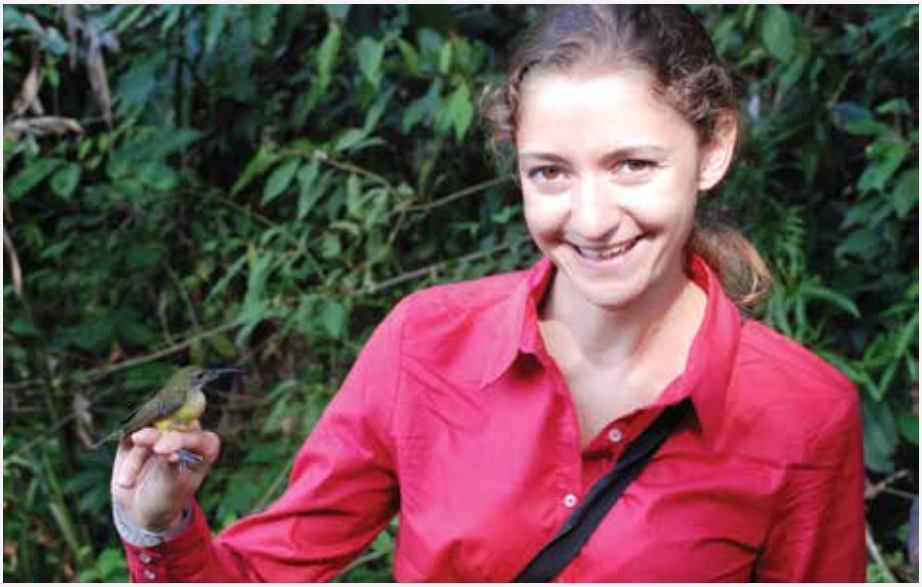
Value-based decision-making in *Drosophila melanogaster*

Sophie Perry, St Peter's College

Anon

I investigated which neurones are required for flies (*Drosophila melanogaster*) to make relative aversive choices. I trained the flies using Pavlovian conditioning by subjecting them to 30V and 60V electric shocks paired with different odours, and then tested their preference between the odours. Flies that made the correct choice (the odour paired with the smaller electric shock) had correctly carried out a relative aversive decision. By experimenting on different lines of flies, I concluded that octopamine was not necessary to make these relative decisions. Furthermore, I identified specific dopaminergic neurone subsets that were crucial to making relative aversive decisions.

Support and Legacy Gifts for student travel and field work



Owen Lewis

Florence Albert-Davie, then third-year Biological Sciences undergraduate on Borneo field course

For many years, the Oxford degree course in Biological Sciences (and indeed, Botany, Zoology and Agricultural & Forest Sciences) has actively encouraged students to travel overseas to attend an organized field course, or students may organize expeditions sanctioned by the Oxford University Exploration Club, or may choose to experience field work and volunteering with outside institutions or NGOs. Many students also elect to carry out their Honours Research Project overseas.

A feature of all these trips is that flights, subsistence and field equipment cost a lot of money. Undergraduate fees are not able to support such ventures in full, since while they contribute to tuition and equipment costs, they cannot stretch to travel and subsistence. The Departments and the University have some named trust funds that students can apply to, with several students obtaining contributions to their travel and research each year, but they currently fall far short of what is required. Some colleges also provide travel grants, but these are also very limited.

The combined effect is that the opportunity for field work and study is now at risk. Conservation and understanding of global biodiversity is crucial for all our futures, yet Oxford students are having difficulty gaining first-hand experience of such issues through lack of funding.

With your help we wish to create a larger travel bursary fund to which students can apply for funds for overseas travel, building upon the foundations we have in place. There are several ways to donate money to the University of Oxford, either through its colleges or its departments, and we are well aware that you frequently get asked for financial support. However, we wonder if you would consider making a gift to a new Biology at Oxford Travel Bursary Fund? Your donation however large or small, a one-off or on a regular basis, will open up opportunities for talented students to study overseas, opportunities that otherwise would be denied to them. There are also tax-efficient ways of making a legacy gift in wills. If you are interested in making a donation, please contact Mrs Hannah Curwell-Parry, Hannah.curwell-parry@devoff.ox.ac.uk.

Martin Speight

Undergraduate student projects

Do harbour seals have personalities?

Amber deVere, Somerville College

Harbour seals (*Phoca vitulina*) are thought to share characteristics with many animals in which personality has been found. However, such traits have never been investigated in this species. In my honours project, I studied five harbour seals and was able to demonstrate that they exhibited three of the five human personality factors. These personality factors were: neuroticism, extraversion, and openness to experience. These results place harbor seals in a very small and select group of mammals who share these factors with humans.

Comparing the biodiversity of Indian Ocean Anomura

Alexander Kolliari-Turner, Lady Margaret Hall

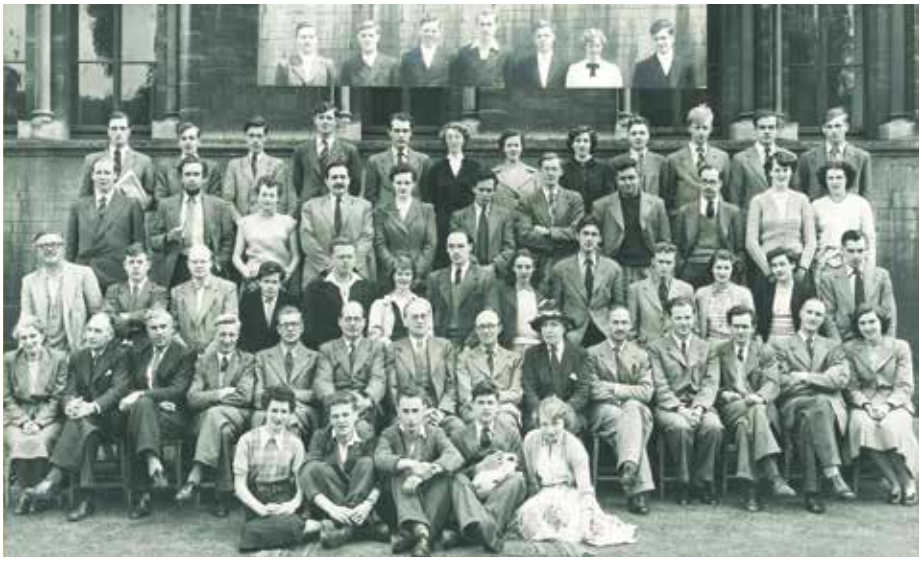
I used DNA barcoding techniques to compare the diversity of porcelain and hermit crabs of the Chagos Archipelago and Madagascar, to test if the Northern Mozambique Channel is a diversity hotspot for these taxa. For both types of crab, mean MOTU (Molecular Operational Taxonomic Units) richness per dead coral colony was shown to be similar in Chagos compared to two sites in Madagascar. My results indicate that the Northern Mozambique Channel, which has been shown to be a diversity hotspot for scleractinian corals in the Indian Ocean, does not necessarily harbour the highest levels of marine biodiversity for all taxa.

Can giant clams counter eutrophication of coral reefs?

Wanting Zhao, Hertford College

Giant clams are the world's largest living bivalves and are found on coral reefs throughout the Indo- Pacific. While they harbour symbiotic zooxanthellae that carry out photosynthesis, they also filter-feed like other bivalves. My project aimed to evaluate their role as potential counteractors of eutrophication on coral reefs, and presented the first known algal clearance rate data for juvenile *Tridacna maxima*. All experimental work was done at the Tropical Marine Science Institute in Singapore.

Memories of the Zoology Degree Course 1949–1952



I suspect that some parts of the Zoology degree in the 1950s had not changed for many decades. Particularly prominent was the Animal Kingdom course which lasted for six terms, spread over two years, and went sequentially through all taxa. Practicals were a mixture of observing specimens preserved in formalin, dissection, microscope work and occasional tours around exhibits in the University Museum. Nearly all academic staff gave lectures on taxonomic groups in which they had no interest. The other half of the course, however, covered new ideas in ecology, population biology (particularly birds), animal behaviour, genetics and evolution. Professor Hardy was the driving force behind innovative teaching, and he made sure the course was full of excitement and fun. New ideas and current research grabbed our attention and stimulated our minds. The lectures for this part of the course took place late in the day which caused Dr Peter Brunet to remark one day '*All the interesting lectures take place after 5pm*'.

Professor Sir Alister Hardy

Professor Hardy's lectures were peppered with phrases such as '*When I was on the Discovery in 1925*' which left his students in no doubt about the influence of this period in shaping his distinguished career. During his lectures he was continuously drawing exquisite pictures of the animals he was describing; these were all in white chalk on a blackboard. As a student you only had time either to write notes or to copy the drawings: an agonising decision. The practical examinations for Finals were also memorable. We arrived in the teaching laboratory in the old Zoology building next to the University Museum of Natural History. As soon as we had taken our places, Dr William Holmes said '*Ladies and Gentlemen you may take off your caps and gowns. Ladies and Gentlemen you may smoke*'. It was an all day exam, and when it was time for the lunch break, Professor Hardy told us to put on our caps and gowns and bring our packed lunch. He led the group of 20 undergraduates into the University Parks where we all sat down on the grass to eat our lunch with Professor Hardy invigilating, to make sure we did not exchange any information. Lunch over, he marched us all back to the laboratory to continue the practical examination.

Professor Niko Tinbergen

Professor Hardy came into the lecture theatre one day and announced '*We have managed to attract Dr Niko Tinbergen to join the Department of Zoology*'. The undergraduates were delighted at the news. When Dr Tinbergen was giving one of his first lectures, an undergraduate walked in late. Niko drew himself up to his full height and said 'Nobody walks into my lectures late'. The undergraduate audience was stunned. But Niko was remembered by all students for his kind, helpful and friendly personality. Seminars which took place at his house on Friday evenings during term were particularly exhilarating.

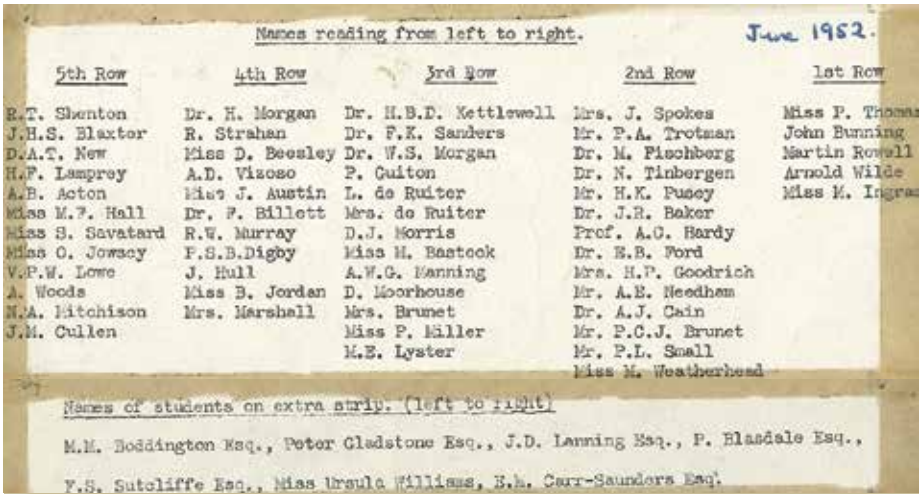
David Lack and Bernard Tucker

Bernard Tucker died in 1950, and the following year David Lack took his place delivering the lectures on birds. The contrast between the content of the two lecture series was striking: Bernard Tucker's lectures were all about anatomy and morphology, while David Lack's were on population ecology and evolutionary biology.

Charles Elton and Ecology

Charles Elton delivered a lengthy series of excellent lectures on ecology but they involved no field work. The only practical classes in ecology were two afternoons in Wytham Woods studying the invertebrate fauna of leaf litter, conducted by Dr B M Hobby from the Hope Department of Entomology. Dr Hobby was a portly gentleman who wore a black suit for these two afternoons of field work. On one occasion he was on his knees pointing out the inhabitants of the leaf litter to the assembled students and had difficulty in rising, when he remarked '*Oh to be a beetle*'.

Ursula Bowen (née Williams) (St Anne's 1949)
URSULA DIED PEACEFULLY ON 28 APRIL 2015



Names reading from left to right. June 1952.

5th Row	4th Row	3rd Row	2nd Row	1st Row
R.T. Shenton	Dr. H. Morgan	Dr. H.B.D. Kettlewell	Mrs. J. Spokes	Miss P. Thomas
J.H.S. Blaxter	R. Strahan	Dr. F.K. Sanders	Mr. P.A. Trotman	John Bunning
D.A.T. New	Miss D. Beesley	Dr. W.S. Morgan	Dr. M. Fischberg	Martin Rowell
H.F. Lamprey	A.D. Visoso	P. Cuiton	Dr. N. Tinbergen	Arnold Wilde
A.B. Acton	Miss J. Austin	L. de Ruiter	Mr. H.K. Pusey	Miss M. Ingra
Miss M.F. Hall	Dr. F. Billett	Mrs. de Ruiter	Dr. J.R. Baker	
Miss S. Savatard	R.W. Murray	D.J. Morris	Prof. A.C. Hardy	
Miss C. Jowsey	P.S.B.Digby	Miss H. Bastock	Dr. E.B. Ford	
V.P.W. Lowe	J. Hull	A.W.G. Manning	Mrs. H.P. Goodrich	
A. Woods	Miss B. Jordan	D. Moorhouse	Mr. A.E. Needham	
N.A. Mitchison	Mrs. Marshall	Mrs. Brunet	Dr. A.J. Cain	
J.M. Cullen		Miss P. Miller	Mr. P.C.J. Brunet	
		M.E. Lyster	Mr. P.L. Small	
			Miss M. Weatherhead	

Names of students on extra strip. (left to right)

M.M. Boddington Esq., Peter Gladstone Esq., J.D. Lanning Esq., P. Blasdale Esq.,

Y.S. Sutcliffe Esq., Miss Ursula Williams, E.A. Carr-Saunders Esq.

Global food security

Food prices have largely been declining throughout the last 100 years and today we in the rich world spend less on food (~10% of our income) then any other society in history. There have been periods of higher food prices, most notably during the World Wars and the Oil Crisis of the 1970s, but until recently prices were decreasing and relatively stable. There has also been significant process in ending global hunger: the number of people going to bed hungry has declined despite the overall human population still increasing.

It was thus something of a surprise when food prices began to rise in 2008 and since then we have seen the greatest period of food price volatility for over 40 years (though currently food prices are falling). There is still controversy over exactly why this happened but a series of bad harvests and historically low grain reserves played an important role. But so too has the slow rise in demand for food from a larger global population, and a greater number of more wealthy people who demand a better and more varied diet. The combination of secular increases in demand plus increasing supply side pressures – competition for land and water, climate change – suggest pressure on the food system is likely to continue.

In response to this the Oxford Martin School has initiated a Programme on the Future of Food to bring together everyone in the University working on the food system and to encourage interdisciplinary research. The Programme is run out of the Zoology Department and has a website (www.futureoffood.ox.ac.uk) describing the University's activities in this area. It has also supported three interdisciplinary research projects as well as a number of initiatives linking University researchers with policy makers in the UK and internationally.

Plant Sciences and Zoology are already active in a number of areas of importance to food security. One of the three major themes of Plants for the 21st Century Institute (also supported by the Oxford Martin School) is crop improvement to bolster food security. Here Jane Langdale leads projects concerned with modifying photosynthesis to improve yields in rice, Nick Harberd studies stress resistance in wheat, Liam Dolan works on modifying root architecture to enhance water and nutrient uptake, and Lee Sweetlove works on plant metabolism. In Zoology, Tom Pizzari and Marian Dawkins have shown that careful monitoring and attention to chicken welfare can improve productivity while Adrian Smith studies the immune response of livestock to parasite infection.

CIMMYT

Rice farmer, Vietnam

Researchers in the two Departments also work across the University in interdisciplinary projects. Ecologists from Zoology, Plant Sciences, Geography and different economics departments study how natural environments provide "ecosystem services" that benefit agriculture. Mike Bonsall from Zoology works with the Oxford Institute of Population Aging to study how an aging farming work force controls agricultural pests in Viet Nam. And a grand coalition led from Medical Sciences and including economists, geographers, development specialists and biologists are modifying an economic model of the global food system so that it can study not only food prices but also health and environment outcomes.

Charles Godfray

IRRI

Rice varieties

Genomics for more resilient forests

Genetic diversity and adaptation

Forest health is being challenged in many parts of the world of world due to emerging diseases and insect pests associated with globalization and other environmental changes. In the UK alone, the number of new diseases affecting forest trees has grown steadily, now reaching 20 per year on average. One approach to boosting the resilience of such threats is to maintain or enhance the genetic diversity within forest tree species. High levels of genetic diversity are believed to provide a reservoir of adaptations to overcome changing or adverse conditions. We are using genomics to uncover specific examples showing the relationship between genetic variability and mechanisms such as resistance to insect pests.

Figure 1. Discovery of a resistance gene against Spruce Budworm. Genomic screening of resistant and non-resistant trees for 24,000 genes identified a beta-glucosidase (bglu-1).

Forest tree defences against insect pests

Forest insect pests can be both environmentally and economically catastrophic when they reach epidemic proportions. One of the most significant North American pests is the spruce budworm, a small moth whose larvae invade the growing shoots of spruce and fir trees, causing widespread devastation. From 1950 to 1993 a spruce budworm epidemic swept across eastern Canada, covering an area of almost a million square kilometres; the pest killed up to 58% of the trees it attacked, and had a disastrous impact on wood yields.

Research in my group with colleagues (at Laval University and the University British-Columbia) studied recently discovered resistant trees which produce high levels of a chemical which is toxic to the spruce budworm larvae. Critically, we showed for the first time that this is linked to the expression of a single gene, which encodes an enzyme that makes the toxin from other chemicals in the trees' cells. Gene expression was up to one thousand times higher in resistant white spruce trees than in non-resistant trees. In addition, resistant trees timed their peak gene expression to coincide with the final larval stage, in which most of the damage occurs. We discovered this gene by screening the expression of nearly 24,000 different gene sequences in the foliage on which the budworm feeds.

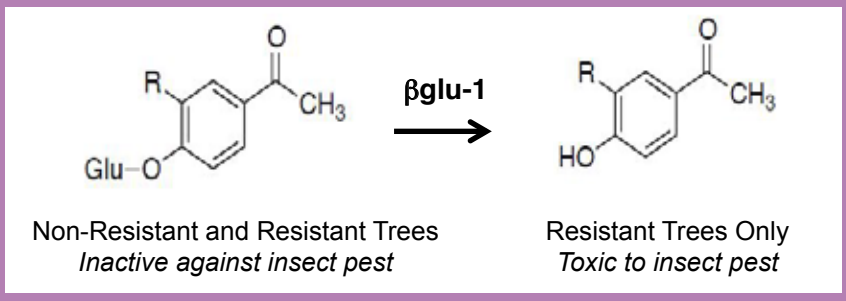


Figure 2. Reaction catalyzed by the bglu-1 gene to produce insect acetophenones that are toxic to the Spruce Budworm.

Using results of genomics research to enhance forest resilience

We found that these resistance traits are heritable, which has important implications for future forest management. It means that there is now a tool for the selection and breeding of white spruce trees which are most likely to be resistant to this highly destructive pest. Previously there was no basis on which to do this, and therefore there was no guarantee that new plantations would be better at surviving an epidemic than natural forest. We extended our analysis to include trees from a broad geographic area and found that the resistance traits we had identified were highly variable, suggesting that resistance breeding could be developed. Genomic selection of resistant strains is likely to be very much quicker than current tree breeding programmes, which can take up to 30 years to establish a successful new strain. In contrast, genomic selection can cut the test period down to 2 years and reduce the whole cycle to less than 10 years. The outcomes of our genomics study are also useful for identify existing forests with high levels of tolerance and susceptibility and thus aid protection management planning.

John MacKay

Community-based conservation in Madagascar

Matthew Farman

Herizo at a village meeting in Western Madagascar

Madagascar is a global biodiversity hotspot because there are many endemic species (restricted only to Madagascar) and because these species are severely threatened. Since the arrival of humans around 2,350 years ago, Madagascar has lost more than 90% of its original forest. Today about 80% of people live in rural areas and depend strongly on natural resources to survive. The main threats to the natural environment are slash-and-burn agriculture, charcoal production and illegal timber exploitation. These processes have led to habitat loss for many of Madagascar's endemic species. To address these threats the government has extended the protected area network from 1.7 million hectares in 2003 to the present 6 million hectares, with the aim of eventually protecting10% of the land.

Chris Jackson

Community-based conservation aims to involve local people in the management of natural resources by combining both the conservation of biodiversity and the development of social projects that support education, public health, income generation, and social cohesion. Most conservation NGOs in Madagascar now use this community-based approach since people are highly dependent on their natural resources, and carrying out conservation activities without integrating local people is both unfair and also practically impossible.

Since 2001, I have been developing a participatory ecological monitoring scheme for many of the key threatened species which Durrell Wildlife is trying to protect in five project sites across Madagascar. For example, local people are now monitoring populations of Alaotran gentle lemur *Hapalemur alaotrensis* in Lake Alaotra, the giant jumping rat *Hypogeomys antimena* and the flat-tailed tortoise *Pyxis planicauda* in the Menabe dry forest, and the very rare fish *Oxilapia polli* in the Nosivolo River. I have trained six people per village to collect standardised data on key species and threats and today we have 460 local people from 86 villages involved in monitoring biodiversity. Around 350,000 hectares of forest are now monitored in this way and some of these sites will be designated as new community-managed protected areas this year.

To motivate villages to participate in monitoring and protect the environment, each participating village receives about £1000 per year to be used for projects selected by the people in the village (eg improving water supplies, building schools, agriculture).

This work on empowering local people to manage their natural resources was recognised by my being awarded the Tusk Award for Conservation in Africa, presented by HRH Prince William. The prize of £15000 will be used to further support projects in the communities where I work.

I am now in the 3rd year of my DPhil in the Department of Zoology. My research is on retrospectively testing the effectiveness of this community based approach in protecting biodiversity, maintaining ecosystem services and improving human wellbeing. The results will help identify which components of the Durrell conservation programme have been effective and ensure that scare resources for conservation are targeted at future interventions which are most likely to be successful. I hope the findings will help the government and the managers of protected areas to inform decision making and to improve policy.

Herizo Andrianandrasana

Building animal diversity: fossils and the Cambrian Explosion

Half a billion years ago, life on Earth was very different from today. On land, the continents were barren, but beneath the oceans there was a diverse animal world teeming with strange and unusual forms. At this time, animals were relatively new. The fossil record shows us that nearly every major animal group suddenly appeared and formed complex communities in a relatively quick period of time. This major event is called the "Cambrian Explosion", referring to the geological time period when the explosive radiation took place (Cambrian period: 541–485.4 million years ago).

These ancient fossils provide an extraordinary window through which we can examine early animal evolution, because they preserve soft parts such as skin, eyes, and internal organs in addition to harder parts such as shells. It is even possible to see the last meal in the gut of fossil animals over half a billion years old! The exceptional fossil preservation supplies us with a wealth of information on these strange creatures – and they were indeed very strange, bearing only a little resemblance to modern animals.

Opabinia, for example, is a small, segmented animal with triangular swim flaps protruding sideways, and a head with five eyes and a long hose-like trunk ending in sharp claws. The largest Cambrian animal was *Anomalocaris*, a swimming predator with a wide, flat body, and a head with a pair of stalked eyes, limbs with sharp claws, and circular plate-like jaws with pointy teeth. My research examines the anatomy of Cambrian fossils from sites such as the famous Burgess Shale in the Canadian Rocky Mountains, to help understand the early evolution of animals.

Although they look bizarre at first glance, closer examination reveals that some features of even the strangest Cambrian animals look similar to modern animals. Both *Opabinia* and *Anomalocaris* are segmented – their body is divided into repeated units. This type of body organisation is also seen in modern arthropods, the phylum including lobsters, insects, spiders, and centipedes. Modern arthropods also have jointed limbs consisting of hard sections separated by thin, flexible membranes. This type of limb is also found on the head of *Anomalocaris*, and its eyes are made up of numerous tiny round lenses just like the compound eye of a fly.

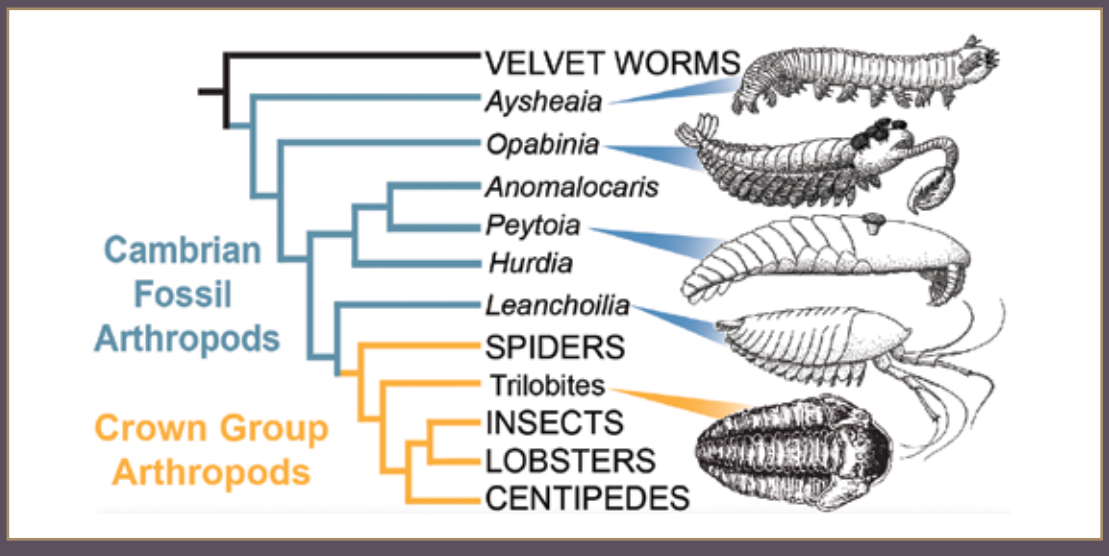
Our research approach is to describe the bodies of Cambrian animals feature by feature. Building up a data matrix of these characters allows us to perform analyses to generate a tree of life showing the relationships between Cambrian and modern animals. Most Cambrian fossils cannot be placed directly within modern animal phyla, because they lack some of the distinguishing features. *Anomalocaris*, for example, has a segmented body, jointed limbs and compound eyes similar to arthropods, but being completely soft bodied, it lacks the external skeleton present in all modern arthropods. *Opabinia* has a segmented body and compound eyes, but lacks jointed limbs and an exoskeleton. *Opabinia*, therefore, is more distantly related to the arthropods than *Anomalocaris*.

Allison Daley

Anomalocaris, the largest animal from the Cambrian Explosion. White arrow indicates the head limb with sharp claws. Top left shows the circular plate-like jaws with spiny teeth

From these analyses, we can see how modern arthropods acquired their most important characters. Cambrian fossils fill in the gap between the arthropods and their nearest living relatives, the onychophorans or "velvet worms". Near the base of this transition are the *lobopodians*, annulated worms with legs such as *Aysheaia*, followed by *Opabinia* and *Anomalocaris*, and ending with arthropods such as *Leanchoilia* and the trilobites. Ultimately, this approach helps us understand how the Cambrian Explosion 500 million years ago established the diversity of major animal groups that we still see today.

Allison Daley



Tree showing how Cambrian fossils (lowercase letters) fill in the gap between modern arthropods and their nearest living relatives, the velvet worms (uppercase letters)

Forest Ecology

The Plant Ecology group in Plant Sciences (Andy Hector & Lindsay Turnbull, PlantEcol.org) studies a range of plants from model systems of annual species to experimental grassland communities and the subject of this piece: forests. Forests, particularly in the tropics, are both hot spots for biodiversity and punch above their weight in terms of their contribution to ecosystem services. For example, forest productivity sequesters important amounts of carbon dioxide that would otherwise add to the ongoing increases in greenhouse gases. We are interested in understanding the maintenance or loss of plant diversity and its consequences for the functioning and stability of ecosystems.

Karin Beer

*Velvet tamarind (*Dialium indium*) a shade tolerant canopy tree belonging to the legume family showing buttress roots typical of many tropical trees*

To address this in tropical forests we have established one of the world's largest ecological experiments. The Sabah Biodiversity Experiment (sabahbiodiversityexperiment.org) has restored 500 ha of selectively logged forest in Malaysian Borneo as 125 experimental plots planted with different mixtures of seedlings of the dominant tree species to study the role of biodiversity in forest ecosystem functioning. Our most recent results come from side experiments addressing drought – a major cause of tree mortality that is predicted to intensify due to climate change.

Strange as it may sound, plant scientists are currently debating exactly how trees die during drought. The most intuitive cause is hydraulic failure – shortage of moisture makes it harder for transpiration to suck water through the plant and out of the leaf stomata until embolisms form in the xylem or these water-transporting tubes collapse leading to desiccation. Plants can avoid this by closing their stomata but this means they cannot photosynthesize leading to the less obvious potential cause of death: carbon starvation. Separating these alternative mechanisms is complicated as carbon stores (non-structural carbohydrates: starch, sugars etc.) are involved in both: plant carbon stores should dwindle following stomatal closure, and they are also thought to play a role in avoiding and repairing the xylem damage that can otherwise cause hydraulic failure (although the details are not well-understood).

Exposing our study species (mainly dipterocarps, the dominant canopy tree group in SE Asian forests) to experimental drought under controlled conditions revealed that species with higher non-structural carbohydrate levels were more resistant but a simple comparison among species is limited since the species differ in many other ways too. We therefore devised a novel approach for manipulating non-structural carbohydrates that allowed us to test their role in drought resistance while leaving potentially confounding plant traits (plant size, root-shoot ratio etc.) unchanged. For each of our ten study species plants with experimentally reduced levels of non-structural carbohydrates were less resistant to drought providing the most direct demonstration yet for their importance in drought tolerance. We were also able to show that it is hydraulic failure that kills these tropical trees (other work suggests conifers may instead close their stomata and starve). Our results suggest that the standard practice of planting single species could produce areas of forest vulnerable to drought when species that have low levels of non-structural carbohydrates are planted over large areas. Using diverse mixtures of species, including those with higher non-structural carbohydrate levels should produce more resilient forest systems. The next El Nino will allow us to test this in the field for real – the Sabah Biodiversity Experiment is ready and waiting.

Andy Hector

A seedling's eye view of the canopy of the old growth forest of Danum Valley conservation area, Sabah, Malaysian Borneo

Chien C Lee

OXFORD UNIVERSITY ALUMNI WEEKEND SEPTEMBER 2015

AFTERNOON EVENT FOR BIOLOGY ALUMNI AND FRIENDS

See our website (www.biology.ox.ac.uk/alumni), and email us on alumni@biology.ox.ac.uk

OXFORD UNIVERSITY ALUMNI WEEKEND

The Departments of Plant Sciences & Zoology
invite you to our Open Afternoon on

SATURDAY 19th SEPTEMBER 2015
12 NOON TO 4PM

ATTRACTIONS WILL INCLUDE

TALKS:

Prof Ben Sheldon, Luc Hoffman Professor of Field Ornithology
Director, Edward Grey Institute &
Associate Head of Zoology Department
"68 years and counting: long term study of great tits in Wytham Woods"

Prof John Mackay, Wood Professor of Forest Science
"Genomics for healthy and resilient forests"

Dr Dora Biro, Associate Professor of Animal Behaviour
"The hows and whys of living in groups: perspectives from birds and primates"

TOURS AND DISPLAYS:

Oxford University Herbaria, Department of Plant Sciences

Biological Sciences Open Day Exhibits, Department of Zoology

Refreshments will be served

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Front cover photo: Allison Daley. Back cover photos: Martin Speight